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ANETHOLE ISOLATION, SYNTHESIS, PROPERTIES: BRIEF OVERVIEW

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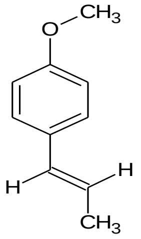
***Abstract**: The aim of the present paper is to review the chemical and biological characteristics of the anethole, its isolation and synthesis. Anethole is one of the main isolates in the global essential oil industry. It is obtained from three types of oils - anise, badian (star anise) and fennel by crystallization and rectification. Anethole is an aromatic substance with exclusive use in the food industry, cosmetics, medicine, technology and other spheres of human life.*

***Keywords**: Anethole, isolation, synthesis, properties.*

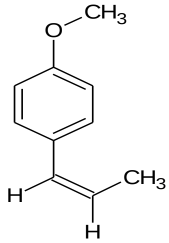
INTRODUCTION

Anethole (1-methoxy-4-(1-propenyl)benzene) is a major component of the essential oils of anise (80%), fennel (50-52%), star anise (70-95%), basil and other plants, and its (*Z*)-form is found in natural products (Fig. 1).

Chemically it belongs to the ethers ($C_{10}H_{12}O$) and is characterized by the following physical parameters: molecular weight 148.20; appearance - white crystalline mass; smell - specific; boiling point 234 °C; relative density 0.988; refraction 1.5615 (Bauer, K., Garbe, D., & Surburg, H., 2001; Georgiev, E., & Stoyanova, A., 2005; Stoyanova, A., 2022).



(*E*)



(*Z*)

Fig. 1. Structure of anethole (E/Z forms)

The purpose of this brief overview is to present the chemical and biological characterization of the aromatic substance anethole, its production and use in human life.

EXPOSITION

The anethole is one of the main isolates in the global essential oil industry. It is obtained from three types of oils - anise, badian (star anise) and fennel through crystallization and rectification (Georgiev, E., 1995).

Crystallization is more labor-intensive than rectification and is associated with more losses, thus it is abandoned in Bulgaria. It includes rectification of the output oil and freezing of the anethole fraction (at about -5 ºC and dilution with 10% ethyl alcohol for better crystallization), centrifugation, separation of the anethole crystals (so called snow) and the liquors. They are frozen two more times at lower temperatures (up to -30 ºC) and during this process more anethole is released. After that the accumulated in the liquors methylhavicol is isomerized using KOH (Fig. 2) and the resulting intermediate product is rectified. Its anethole fraction is refrozen. The isolated from individual oils anethole has a different shade of smell and taste - from star anise oil it has a light fiery vein, and from bitter slice - a slightly bitter aftertaste. The anethole isolated from anise oil and sweet fennel oil has the purest and mildest taste and smell.

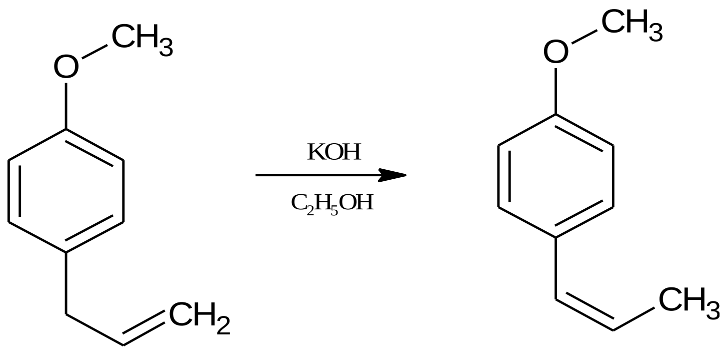


Fig. 2. Isomerization of methylhavicol in anethole

Rectification is the most convenient method for isolating components from essential oils. However, it requires high column resolution and a good relative volatility coefficient between the isolated constituent and the remaining components. The technological scheme for isolating anethole from fennel oil is shown in Fig. 3. At lower temperatures the oil freezes and that is why it is necessary to be melted before entering the rectifier. For greater convenience while observing the technological regime, larger batches are made by mixing. Treatment with NaOH (about 1% of the oil) is carried out in order to saponify the esters, polymers, etc. The hydroxide is introduced as a concentrated solution into the rectifier and boils together with the oil at 120-130 ºC under reversed fridge. Then comes cooling and the hydroxide solution is drained off. The rectification is carried out under vacuum, at the beginning (about 1 h) working under complete dephlegmation, after which the fractions are separated. A high phlegm number is maintained for the frontal and intermediate fractions, and the anethole fraction is separated at a low phlegm number or through the side tube of the rectifier. The front fraction (fennel terpenes) should not contain more than 5% anethole. The intermediate fraction contains about 26% anethole and is re-rectified when sufficient quantity is collected, and the cubic residue (about 0.5%) is discarded. The frontal fractions are used for solvents in the industry or for the synthesis of "Fenarom" (a mixture of oxidized fennel terpenes).

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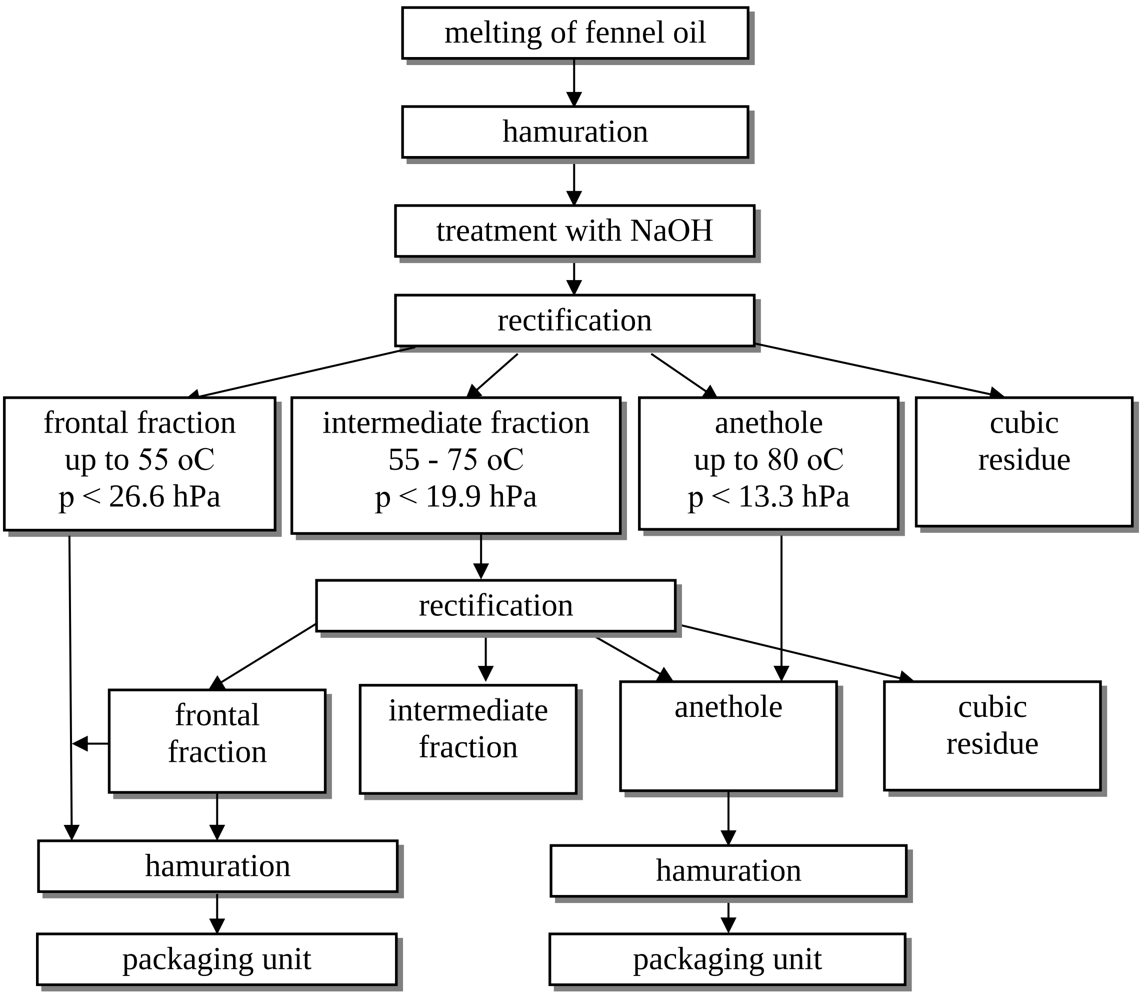

Fig. 3. Anethole isolation

For industrial purposes the anethole is synthesized in significant quantities. Synthetic anethole is a mixture of the (*E*)- and (*Z*)-forms. The (*E*)-anethole is toxic and is separated by high efficiency vacuum rectification. Amounts of above 1% in the mixture reflect om the taste and smell.

Synthetic anethole is obtained in the following ways (Georgiev, E., 1995; Voitkevich, S., & Kheifits, L., 1997).

- *From ρ-methoxypropiophenone in a Meerwein–Pondorf reduction (Fig. 4)*

The reduction is carried out with aluminum isopropylate in an isopropyl alcohol environment at 180-200 ºC or by passing a mixture of *ρ*-methoxypropiophenone and isopropyl alcohol over aluminum oxide at 140-160 ºC.

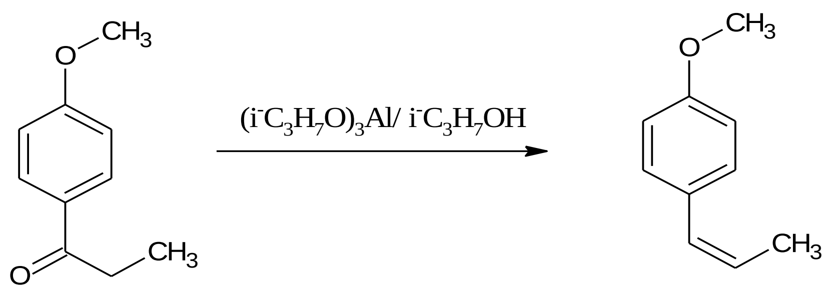

Fig. 4. Synthesis of anethole from *ρ*-methoxypropiophenone

- *From anisole and propionic anhydride by the Heifitz method (Fig. 5)*

Initially, the anisole and propionic anhydride condense in the presence of $ZnCl_2$ and $FeCl_3$ to ρ-methoxypropiophenone, which is reduced to alcohol and its dehydration results into anethole. The yield is 70-75% of the theoretical relative to anisole.

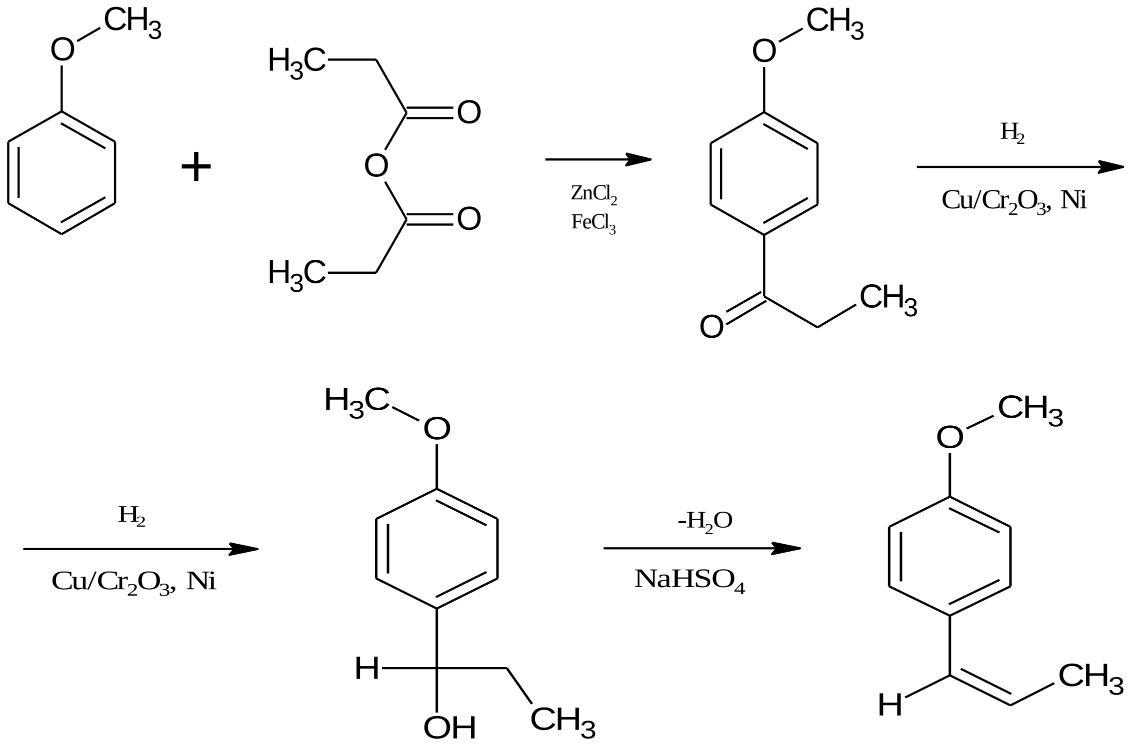

Fig. 5. Synthesis of anethole from anisole and propionic anhydride

- *by chloroalkylation of anisole (Fig. 6)*

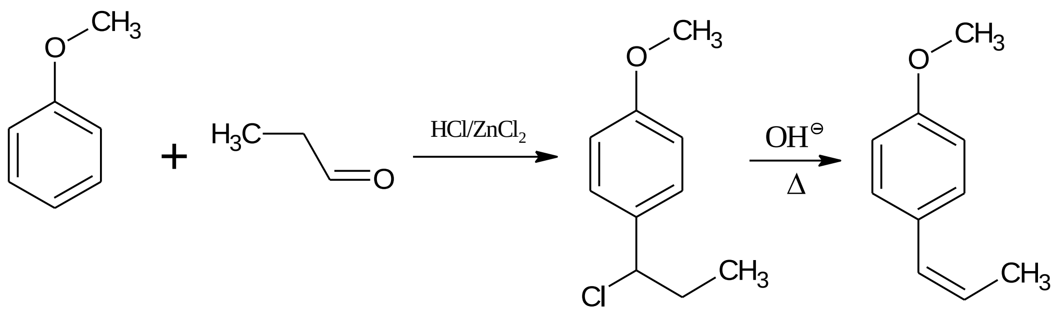

Fig. 6. Synthesis of anethole by chloroalkylation of anisole

The finished anethole is a snow-white crystalline mass or a colorless oily liquid (depending on the temperature) with a pleasant specific smell and sweetish taste. It has the following characteristics: relative density (d^{25}) from 0.984 to 0.987; refraction (n_D^{25}) from 1.558 to 1.561; melting point 20.5 to 23.0 °C; freezing point from 20.0 to 22.0 °C; solubility of 1:2 in 90% ethyl alcohol. It is stored in the dark in glass bottles, aluminum or tinned cans/tanks and in galvanized barrels. During long-term storage in light, it partially turns into photoanethole and loses its ability to crystallize.

The anethole is characterized by various biological properties - antimicrobial, antioxidant, anti-inflammatory, *etc*. (Freire, R., Morais, S., Catunda-Junior, F., & Pinheiro, D., 2005; Huang, Y., Zhao, J., Zhou, L., Wang, J., Gong, Y., Chen, X., Guo, Z., Wang, Q., & Jiang, W., 2010; Giustarini, D., Fanti, P., Sparatore, A., Matteucci, E., & Rossi, R., 2014; Dolara, P., Corte, B.,

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Ghelardini, C., Pugliese, A., Cerbai, E., Menichetti, S., & Lo Nostro, A., 2000; Kim, K., Lee, H., & Seol, G., 2017; Marinov, V., & Valcheva-Kuzmanova, S., 2015; Massimiliano, T., Ballabeni, V., Bertoni, S., Bruni, R., Impicciatore, M., & Barocelli, E., 2007; Ponte, E., Sousa, P., Rocha, M., Soares, P., Coelho-de-Souza, A., Leal-Cardoso, J., & Assreuy, A., 2012), which is why it is used in different areas:

- in the food industry (in aromatic compositions of strawberry, apricot, vanilla, honey, etc.),
- in the spirits and liqueur industry (mastic, aniseed, etc.),
- in cosmetics (in aromatic compositions for toothpastes and mouthwashes, as well as in perfume compositions for soaps),
- in tobacco sauces,
- in medicine and pharmacy,
- in technology,
- it is also used as a raw material for the synthesis of anisaldehyde (obepine) and other aromatic substances. Oxidation of anethole (Fig. 7) results into anisaldehyde and *p*-methoxybenzoic acid (Berger, R., 2007). Anisaldehyde is a synthetic aromatic substance with a hawthorn flower smell, which finds exclusive use in the perfumery, as well as for the synthesis of other aromatic substances.

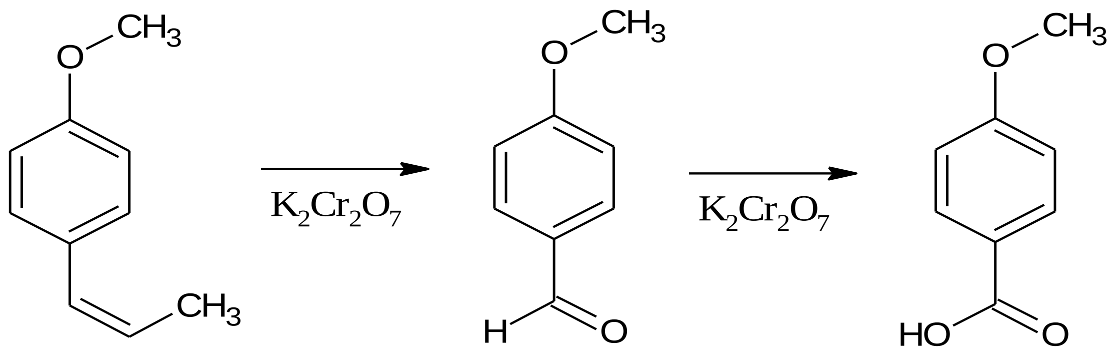

Fig. 7. Synthesis of anisaldehyde (obepine) and *p*-methoxybenzoic acid of anethole

The concentration of anethole in the finished products (%) is as follows: soaps 0.008-0.06; detergents 0.001-0.006; creams and lotions 0.0025-0.01; perfumes 0.054-0.25; in foodstuffs 11-340 mg/kg, in chewing gum up to 1.5 g/kg (Georgiev, E., & Stoyanova, A., 2005).

It has been found that taken orally in large quantities, however, the anethole affects the central nervous system, which is why essential oils containing anethole have limited use in the food industry and cosmetics (Aschenbeck, K., & Hylwa, S., 2017; Horst, N., Leysen, J., Mellaerts, T., Lambert, J., & Aerts, O., 2017; Poon, T., & Freeman, S., 2006).

CONCLUSION

The anethole is an aromatic substance with exclusive use in the food industry, cosmetics, medicine, technology and other areas of people's lives.

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